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WEATHER-AGILE RECONFIGURABLE AUTOMATIC TARGET RECOGNITION SYSTEM

DEDICATORY CLAUSE

[0001] The invention described herein may be manufactured, used and licensed by or for the Government for governmental purposes without the payment to us of any royalties thereon.

BACKGROUND OF THE INVENTION

[0002] On many battlefields, well-known target signatures are distorted by real-world effects, such as various and varying environmental conditions. Further, new, heretofore-unknown targets emerge that need to be defined. As a consequence, updates of a target acquisition or automatic target recognition (ATR) knowledge base are and continue to be a necessity for autonomous precision strike weapons. Such autonomous precision strike weapons utilize all possible target sensing means except direct laser designation of the targets.

[0003] ATR systems that use some type of pattern recognition need some form of knowledge or training database resident in the systems for proper operation. Since the performance of any ATR system is limited by these training data and often even known targets are obscured by camouflage and other means, most real-world applications require some real-time updates (i.e. retraining) of

the target knowledge database. This requirement also holds true for any new mobile or fixed targets. This "real-time" retraining is referred to as rapid retraining or rapid target update.

[0004] In an ATR system, the typically required information for the pattern recognizer consists of target and background/clutter signatures in the electromagnetic band of interest. The robustness of ATR performance is usually quantified by correct classification of targets in some form, such as recognition or identification and false alarms defined as either clutter or misclassifications. The best ATR for any specific system application can be selected from known algorithms that are amenable to rapid retraining and also appropriate for the timeline for the specific application at hand. To maintain the ATR robustness through rapid target updating, however, the ATR must have the flexibility to be reconfigured in response to the target scene information provided by the surveillance means. Part of this updating process includes establishing metrics of the clutter in the target scene so that the criteria on ATR performance can be established for the specific target environment.

[0005] In general, multiple simultaneous weapon engagements are desired to eliminate multiple targets in a very short period of time. The rapid retraining of multiple weapons is restricted by the limitations of available and compatible sensors.

SUMMARY OF THE INVENTION

[0006] Applicants' ATR system is weather-agile because it is comprised of a first target sensing means, either singular or plural, that is (are) capable of surveilling the target scene in foul or fair weather, and a second target sensing means, comprised of a group of sensors. At least one sensor from the group comprising the second target sensing means is mounted on one of several available weapons. These sensors can also sense targets in either foul or fair

weather. Applicants' ATR system makes it possible to use dissimilar sensors in surveillance and in the weapons, while not excluding the use of similar active or passive sensors when conditions allow.

[0007] The first and second sensing means communicate through a control center so that ultimately, among the several weapons available, the most strategically located (based on its trajectory relative to the selected target) and equipped (relative to the weather) weapon is activated for the destruction of a selected target. The control center accomplishes the communication by receiving the sensed target signature from the first sensing means, processing the signature using database already resident in the center and transmitting the processed target signature to the weapon possessing the greatest potential for successfully destroying the target.

DESCRIPTION OF THE DRAWING

[0008] Figure 1 illustrates the Weather-Agile Reconfigurable ATR System having multi-spectral target sensing means on both the surveillance platform and the weapons.

[0009] Figure 2 shows the Reconfigurable ATR system wherein both the surveillance and weapon sensors are synthetic aperture radars (SAR's).

[0010] Figure 3 shows the Reconfigurable ATR system wherein the primary target sensor on the surveillance platform is a SAR and the secondary target sensor on the weapon is a laser radar.

[0011] Figure 4 shows the Reconfigurable ATR system wherein the primary target sensor is a SAR and the secondary target sensor is an electro-optical sensor.

[0012] Figure 5 shows the Reconfigurable ATR system wherein both the surveillance and weapon sensors are electro-optical sensors.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0013] Refer now to the drawing wherein like numbers represent like parts in each of the several figures, solid lines with arrowheads represent signal paths and dotted lines with arrowheads represent the weapon trajectory. With reference to the drawing, different combinations of various types of primary and secondary sensing means are presented for changeable climatic conditions.

[0014] Figure 1 is a diagram of the Weather-Agile Reconfigurable ATR System having multi-spectral target sensing means on both the surveillance platform and on the weapons. The primary sensing means is multi-spectral sensor 101 mounted onto airborne surveillance platform 105 from which it surveils target scene 109 through any kind of weather that may exist between the platform and the target scene. From this surveillance activity, the multi-spectral sensor produces target signature information that is descriptive of the type of target detected. This target signature information is downlinked to control center 111, also through any kind of weather condition.

[0015] The control center has therein pre-existing database which pertains to, among others, target spectra, terrain and material classification, topography, atmospheric correction for converting radiance to reflectance, the capabilities and limitations of the sensing means on the available weaponry and the location of the weaponry. The control center transmits this database, to the extent practical, to surveillance platform 105 to optimize the transfer between the primary sensing means and the control center of the most useful information for rapid retraining.

[0016] Upon receipt of the target signature information, the control center processes (reformats) the information to discover the type and location of the detected target and selects, among available weapons 107, the particular weapon that is most likely to succeed in destroying the detected target. The likelihood of success is determined based on the location of the weapon, its predicted trajectory relative to the location of the target and the wepon's destructive

capabilities. The selected weapon confirms to the control center the receipt of the update. Thereafter, the weapon is launched toward the target. In the embodiment shown in Figure 1, the suitability of secondary sensing means 103 on the weapon for detection of the target through the weather encompassing the trajectory is deemed irrelevant since it is a multi-spectral sensor capable of functioning in all weather conditions.

[0017] Figure 2 shows the Reconfigurable ATR system wherein both the surveillance and weapon sensors are synthetic aperture radars (SAR) 201 and 203, respectively. Such active sensors of the same type being used together offers the highest potential for image matching of spatial features. If SAR sensors having different resolutions (example: higher resolution on the surveillance and lower resolution on the weapons) are used, the different resolution images of the same scene can be fused using the method taught by Mario Costantini et al. in their article "The Fusion of Different Resolution SAR Images," in the PROCEEDINGS OF THE IEEE, vol. 85, No. 1, pages 139-146. By fusing, a better match between the sensors can be achieved. Accordingly, the fusion techniques described in the article are incorporated herein.

[0018] The SAR-to-SAR configuration is particularly useful when both sensors must operate in foul weather because when the weather is poor, electro-optical sensors or hyperspectral sensors provide little or no capability. In Figure 2, SAR imagery is collected over target scene 109 in foul weather indicated by clouds 205. In addition to clouds, the foul weather can be fog or rain. The SAR image collected must include both potential targets, confusers and clutter so that eventually a high level of precision strike can be performed with virtually zero false alarms and avoid unintended targets. The collected SAR imagery is compressed and down-linked to the control center with the position coordinates of the potential targets or "regions of interest" and the position of the surveillance platform relative to the available weapons. Upon receipt, the control center decompresses the imagery, performs coordinate transformation for

a specific weapon trajectory and performs the discrimination and classification processes using synthetic discrimination function filter. From this is derived the target spatial information which is formatted to allow rapid retraining of weapons with synthetic aperture radar 203. It is noted that in the future, the control center itself may potentially be eliminated or bypassed and its functionality placed either at first or second sensing means or partitioned between the two. This direct communication between the sensing means would help minimize the latency and result in improved target elimination timeline.

[0019] The target spatial information derived by the control center can also be transmitted to weapons with laser radar 301 or electro-optical or hyperspectral sensor 401, as illustrated in Figures 3 and 4, respectively, if the weather encompassing the selected weapon trajectory is fair. A method for fusing SAR and hyperspectral image data sets over the same area is taught by Su May Hsu et al. in "SAR and HSI Data Fusion for Counter CC&D," <u>The Record of the IEEE 1999 Radar Conference</u>, pages 218-220. Therefore, the method of co-registering the images using references to terrain features, as described in the Hsu article, is incorporated herein.

[0020] If the weather conditions allow, use of purely passive sensors such as electro-optical sensors 501 and 401 is highly desirable because it minimizes the potential of alerting the targets during multiple simultaneous weapon engagements. This is illustrated in Figure 5. Substitution of the electro-optical sensors with hyperspectral sensors may afford the ability to detect specific materials used in a target object.

[0021] The embodiment, depicted in Figure 1, utilizing multi-spectral sensors both on the surveillance platform and on the non-reusable weapons may entail substantial costs. An alternative is to use simultaneously the combinations of various types of primary (on the surveillance platform) and secondary (on the weapons) sensing means as described above with reference to Figures 2 through 5. Many surveillance platforms having thereon various types of primary sensing

means may be deployed, all communicating with a common control center. Likewise, many groups of weapons can be positioned at various locations, each group in turn comprising multiple weapons having different secondary sensing means. In this way, great flexibility is built into the Weather-Agile Reconfigurable ATR system to achieve the least wasteful and most accurate precision strikes against selected targets.

[0022] Although a particular embodiment and form of this invention has been illustrated, it is apparent that various modifications and embodiments of the invention may be made by those skilled in the art without departing from the scope and spirit of the foregoing disclosure. Accordingly, the scope of the invention should be limited only by the claims appended hereto.